the theoretical results of Fig. 2 of [1] show that for L_f = 2µm, there are two values of L_1 at which minimum second-harmonic distortion can be achieved. This cannot be predicted from eqn. 7. Furthermore, for M_{im} =0.5 the approximation of the term $(\sqrt{(1-m_i)} - \sqrt{(1+m_i)})$ using eqn. 6 results in an error of the order of 3.5%. Such an error cannot reliably yield harmonic distortions of the order of −81dB.

It appears, therefore, that eqn. 6 of [1] cannot reliably predict the harmonic performance of the second generation SI memory cell.

© IEE 1998 3 August 1998
Electronics Letters Online No: 19981528

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Active aperture-coupled leaky-wave antenna

Nien-An Kao, Cheng-Chi Hu, Jin-Jei Wu and C.F. Jou

An active aperture-coupled leaky-wave antenna which is integrated with a varactor-tuned high electron mobility transistor voltage-controlled oscillator (HEMT VCO) is presented. To excite the first higher mode of the microstrip, the aperture-coupled structure is used and a sequence of covered wire is added at the centre of this antenna to suppress the dominant mode. The measured H-plane main beam can be continuously scanned 10° as the HEMT VCO frequency is varied from 9.05 to 9.5GHz. This feeding structure is very suitable for active phase antenna array applications.

Introduction: Recently, active antennas in which an active component (Gunn diode or field effect transistor) is integrated directly into each radiation element have received much attention. Several novel architectures have appeared in the literature [1, 2] in which the active element is incorporated with a planar antenna. In this Letter we describe our development of an X-band leaky-wave antenna (LWA) on one substrate, which is coupled to a voltage-controlled oscillator (VCO) feed on another parallel substrate. The signal is coupled through an aperture in the ground plane that separates the two substrates (Fig. 1). This aperture-fed structure was proposed by Pozar [3]. Because the HEMT VCO can be placed below the antenna, the size of the whole circuit can be reduced. This structure has the advantage that interference between the feeding network and the radiation element can be avoided. In addition, the LWA has other excellent advantages such as frequency scanning and narrow beamwidth, and it is very suitable for integrated antenna array applications [4]. In this Letter, the LWA is fed from the aperture to excite the first higher mode [5], leaks are in the form of a space wave, and covered wires are added at the centre of the microstrip LWA to suppress the dominant mode [6]. By controlling the frequencies of the varactor-tuned HEMT VCO, the main beam can be scanned in the elevation plane.

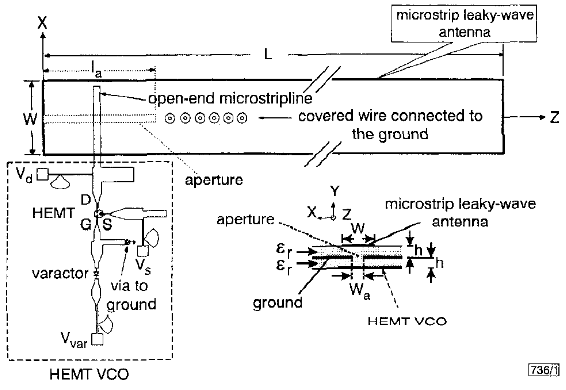

Fig. 1 *Configuration of X-band active aperture-coupled LWA*

L = 125mm, W = 12mm, ε_r = 2.2, h = 0.508mm, l_a = 30mm, w_a = 2.2mm, V_d = 2V, V_s = 0V

Design and measurement result: Fig. 1 shows the configuration of the X-band active aperture-coupled LWA. The whole circuit is designed and fabricated on an RT/Duroid substrate with ε_r = 2.2 and a thickness of 20mil. The varactor-tuned HEMT VCO was designed using a small-signal iterative procedure. Short-circuited microstrip feedback is used in series with the gate to provide the device with negative resistance. A 1.54mm wide openend microstripline is connected to the drain and it extends 13.27mm past the aperture. A tuning varactor which is connected to the gate is used to determine the oscillation range of this VCO. The aperture is placed above the open-end microstripline, and its dimensions are determined by the impedance matching for coupling maximum power to the antenna. The obtained aperture width is 2.2mm when the aperture length is chosen to be 30mm.

To understand the radiation characteristics of a microstrip LWA, we obtained its complex propagation constant $\beta + j\alpha$ in the leaky (radiation) region, where β is the phase constant and α is the attenuation constant. We employed the rigorous (Wiener-Hopf) solutions of [7] to obtain the normalised complex propagation constant. θ is the elevation angle between the main-beam direction and the end-fire direction, and it can be calculated using the approximation $\theta = \cos^{-1}(\beta/k_0)$. Fig. 2 shows the normalised complex propagation constant against frequency. The measured return loss $|S_{11}|$ of this antenna is also shown in Fig. 2. We found that the return loss is lower in the leaky region. For $\beta < k_0$, power will leak into a space wave in addition to the surface wave. According to this relationship, we can predict that the main beam position will be a function of the frequency.

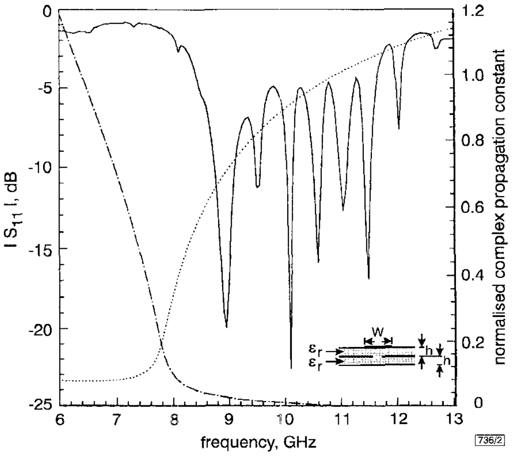

Fig. 2 *Normalised complex propagation constant and measured return loss of aperture-coupled microstrip LWA*

h = 0.508mm, W = 12mm, ε_r = 2.2, k_0: free-space wavenumber
——— $|S_{11}|$
.... β/k_0
—·—· α/k_0

An NE42484C HEMT is used as the active element, and the drain is biased at 2.0V with a drain current of 10mA. An Alpha DVG6064-11 varactor is used as the tuning element. By adjusting the DC bias of the varactor from 1 to 15V, the frequency of the VCO can be varied from 9.05 to 9.5GHz. The active aperture-coupled LWA can be tuned to obtain a beam-scanning angle of 10°. Fig. 3 shows the measurement results of the H-plane radiation patterns for operating frequencies at 9.05 and 9.5GHz. It shows that the main beam swings up from the end-fire direction (Z-axis) as the operating frequency decreases. The maximum effective isotropic radiated power (EIRP) of this antenna is ~13.48 ± 0.34dBm. As the frequency is varied, the variation in the impedance of the active aperture-fed LWA causes the difference in power level. Fig. 4 shows the comparison of the theoretical and measured radiation patterns of this active aperture-coupled LWA at 9.05GHz. The theoretical prediction of the radiation pattern is calculated by applying Huygen's principle at the far-zone field [8, 9]. We can see these two patterns are reasonably similar.

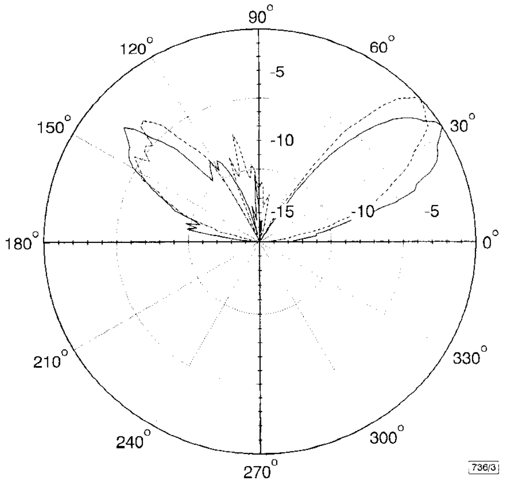

Fig. 3 *H-plane (y-z plane) frequency-scanned radiation patterns*

- - - - 9.05GHz
——— 9.5GHz

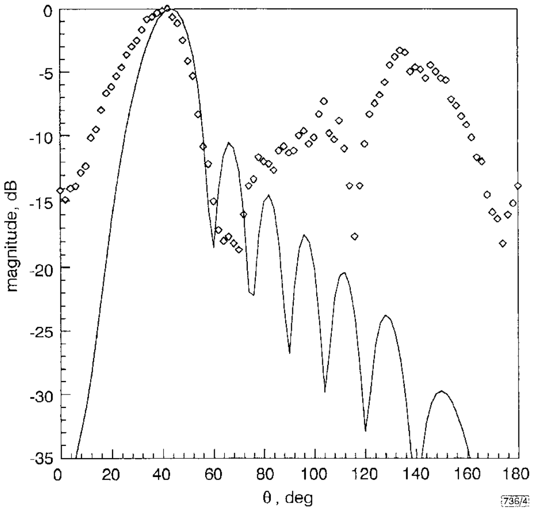

Fig. 4 *Theoretical and measured far field radiation patterns of aperture-coupled leaky-wave antenna at 9.05GHz*

◇ measured
——— theory

Conclusion: An active aperture-coupled LWA has been described. The structure provides excellent shielding to eliminate the interference of the HEMT VCO and the antenna. This active antenna feeding structure is suitable for power combining techniques, active phase antenna array applications, modulated communication links, radar, and other microwave and millimetre-wave applications.

Acknowledgments: This work was supported by the National Science Council under grant NSC88-2213-E-009-099.

16 September 1998
Electronics Letters Online No: 19981539

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Bandwidth enhancement of inset-microstrip-line-fed equilateral-triangular microstrip antenna

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Tzung-Wern Chiou

By embedding a pair of properly-bent narrow slots in an equilateral-triangular microstrip patch, broadband operation of microstrip antennas with an inset microstrip-line feed can be achieved. With the proposed antenna design, the impedance bandwidth can be as large as ~3.0 times that of a corresponding simple triangular microstrip antenna. Some simple design rules for the proposed antenna have also been determined experimentally. The design rules and experimental results are presented and discussed.

Introduction: It has recently been shown that dual-frequency operation can be obtained in a rectangular microstrip antenna with a pair of properly-bent narrow slots placed close to its patch edges; the two operating frequencies have the same polarisation planes and similar broadside radiation characteristics [1]. Ratios of the two operating frequencies as low as ~1.29 have also been obtained. It has been found in the present study that, by applying such a design technique to an equilateral-triangular microstrip patch, similar dual-frequency operation with an even lower frequency ratio can be obtained, which makes it possible for such a design to provide a wide operating bandwidth. In this Letter, suitable parameters for the embedded bent slots for achieving broadband operation of the equilateral-triangular microstrip antenna with an inset 50Ω microstrip-line feed (see Fig. 1) are experimentally studied. Owing to the use of an inset microstrip-line feed, the presented broadband antenna is suitable for applications in microstrip array designs and in integrating with coplanar microstrip circuitry. Experimental results for the obtained broadband performance and some simple design rules determined from the present study are presented and discussed.

Antenna design and experimental results: Fig. 1 shows the proposed broadband equilateral-triangular microstrip antenna with a pair of bent slots and an inset microstrip-line feed. The side length of the equilateral-triangular patch is d. The bent slots consist of two sections of narrow slots with a width of 1mm and a bend angle of 150°. The upper section of the bent slots (denoted here as slot 1) has a length ℓ_1 and is placed close to the side edges of the patch with distance d_s; the lower section of the bent slots (denoted here as slot 2) has length ℓ_2 and is parallel to the centre line (y-axis) of the patch. To obtain a wide operating bandwidth, it was found that the bottom edges of slot 2 should be placed very close